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A REVIEW OF ALUMINIUM ALLOY METAL MATRIX COMPOSITES AND IT'S INDUSTRIAL APPLICATION

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ABSTRACT

Over the last ten years, composites material, plastics and ceramics have been the foremost materials used in many industries. The main goal for the use of matrix composite components in automotive, agriculture and mining sectors is to reduce the weight and to increase the efficiency. As the automotive industries are exposed to restrict fuel economy, to increase comfort and safety of the consumers they turned into lightweight products. The Aluminum metal matrix composites (AMMC's) with high specific stiffness and high strength is the key to solve the above problems as it is lightweight. The application includes robots, high-speed machinery, high-speed rotating shafts and automotive engine and brake parts. This research paper presents a review of advances and trends of aluminium matrix composites for automobile industrial uses. As composite materials are high strength and light weight components, they can be used in automobile and industrial sectors and it leads to the production of advanced material parts with high performance and efficiency.

KEYWORDS: Aluminium Alloy, Automobiles, Fabrication Technique & AMMC's

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Original Article

INTRODUCTION

Aluminium alloys an excellent thermal conductor and low weight material is the most chosen engineering material for mineral processing industries, aerospace and automobile industries [11]. Due to stringent air pollution regulations and the demand of the customers for improved and sophisticated automobile interiors with electronic gadgets this result in additional weight and in turn leads to the increase in the fuel consumption and environmental pollution. This can be cracked by the use of the lightweight product in automobile components and parts that would help in achieving the ever stringent air pollution regulations and also improve efficiency [4, 12].

AMMC's which improves the mechanical and physical properties like as the better weight ratio of strength, greater modulus, strength, lower thermal expansion coefficient, excellent wear resistantance, good corrosion resistantance and better fatigue strength. In general the AMMC's are majorly played in aerospace, military and industrial applications. strengthen the aluminium composite using some of the ceramic material like aluminium oxide, boron carbide, magenisum oxide, silcon carbide, etc., which gives an superior properties of high strength, hardness, wear resistant.

PROPERTIES OF REINFORCEMENT'S MATERIALS

Aluminum oxide particles are a low cost they can be used as an alternative for the casting applications. Silicon Carbide and Boron Carbide are the most commonly used materials in aerospace structural applications [9].

Table 1, shows the list of various ceramic materials with their respective physical and mechanical properties used in the manufacture of modern discontinuously reinforced MMCs. The microstructure should be homogeneous for toughening mechanisms. The Homogeneous here states that the metal particles should be uniformly distributed in the ceramic matrix. Generally the size of the particles which is to be greater than one μm for the reinforced composite material, for that we can strengthen the materials by 2 ways.

Table 1: Mechanical and Physical Properties of Various Ceramic Particles Reinforcements [9]

Rein forcements	Density g/cm^3	Knoop Hardness	Elastic Modulus		Compressive Strength		Thermal Conductivity		Coefficient of Thermal Expansion		Specific Thermal Conductivity. $W.m^2/kgK$
			Gpa	10^6 psi	Mpa	Ksi	W/m-K	Btu - Ft/h – $Ft^2.^0F$	$10^{-6}/k$	$10^{-6}/^0F$	
Al_2O_3	3.82	2150	355	50.89	2600	352.6	12.6	18.96	6.85	12.26	8.2
B_4C	2.42	2750	455	65.34	3100	437.1	29.5	16.85	5.05	9.06	11.8
SiC	3.11	2380	435	62.44	2900	417.1	132.7	76.68	3.43	6.13	41.5
TiC	4.83	2400	345	50.5	2450	372.6	20.59	11.98	7.46	13.35	4.26

So that the first way is the formation of an incoherent interface between the particles and their matrix and another way is particles carries the load along with the matrix, by this process a number of dislocations are generated at the interface, results that materials get strengthened. Strengthening of degree depends on particulate size, shapes and distributions.

FABRICATION PROCESS FOR ALUMINIUM MATRIX COMPOSITES

The challenges ahead in the processing of composite is to homogenize the distribution of reinforcement phases to get a sound microstructure, on the reinforcement phases of composites, which can be a fiber or particles

Initial processes for manufacturing of AMMC's at industrial scale are classified into the following groups.

1. **Solid-State Processes**

Solid-state processes include Powder blending following by consolidation (Powder metallurgy processing), high energy ball milling friction, stir process, diffusion bonding and vapor deposition techniques.

2. **Liquid-Solid Processes**

Compo-casting, semisolid forming.

3. **Liquid State Processes**

Liquid state processes include stir casting, squeeze casting, spray casting and in situ (reactive) processing, ultrasonic assisted casting, vacuum infiltration, pressureless infiltration, and dispersion methods.

From the table 2, the Stir casting method is one the low-cost method for the manufacturing of AMMC's, this method also provides a various list of materials and process parameter conditions. Because of stirring action, this process can manufacture composites with up to 35% of reinforcement materials added to base material what you are chosen and also its provide better bonding to the base materials in aluminum.

Table 2: Analysis of Different Techniques [2]

Method	Range of Shape and Size	Range of Vol Fraction	Damage to Reinforcement	Cost
Powder metallurgy	Wide range, restricted size	0.1 – 0.2	Reinforcement fracture	Expensive
Spray casting	Limited shape, large shape	0.4 – 0.7	No Damage	Expensive
Squeeze casting	Limited by perform shape up to 1.5cm height	Up to 0.6	Severe damage	Moderate expensive
Stir casting	Up to 750kg using wide range shapes.	Up to 0.4	No Damage	Least expensive

APPLICATIONS OF AMMC'S ARE IN INDUSTRIES

The applications of these alloy composites are found mainly in the automotive engineering industry as it the high potential for manufacture low cost and low weight products. Examples are the piston, piston rod, pins, piston rings, cylinder head, main bearing if crankshaft; engine block part-strengthened cylinder blocks. An example of the success of aluminum composite materials is the short fiber reinforced aluminum alloy piston in Fig. 1 shows that strengthened by using Al_2O_3 reinforcement.

The reason we go for the composite materials is for improved high-temperature properties, figure 2 shows the 18% of engine block weight reduced by using aluminum composite. Moreover, aluminum MMC provides superior thermal conductivity and also operating temperature is lower, so that exploitation time is longer.

Figure 1: Short Fiber Reinforced Aluminium Alloy Piston

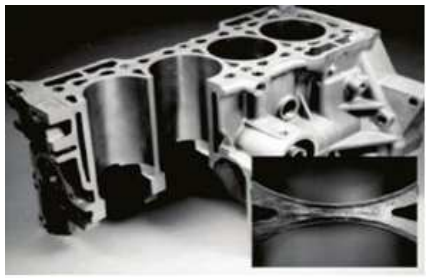

Figure 2: Engine Barrel made of Aluminium MMC

ADVANCED AMMC'S COMPONENTS USED IN VARIOUS AUTOMOTIVE INDUSTRIES

The ultimate objective in the design of metal matrix composites is to fabricate homogeneous, Eco friendly and better manufacturability by different production methods with different volume of fractions, different testing, and analysis.

Table 3: Applications of AMMC in the Automotive Industry [6]

Composite	Manufacturer	Component
Al/Al_2O_3 –Cf	Honda	Engine blocks
Al/SiC_p	Lotus Elise, Volkswagen	Brake rotors
Al/SiC_p	Chrysler	Brake rotors
Al/SiC_p	GM	Rear brake drum for EV-1, drive-shaft, engine cradle
Al/SiC_p	MC-21, Dia-Compe, Manitou	Bicycle fork brace and disk brake rotors
Al/SiC_p	GKN, Duralcan	Propeller shaft
Al/SiC_w	Nissan	Connecting rod
Mg/SiC_p	Dow Chemical	Sprockets, pulleys, covers
Al/Al_2O_3 (saffil) & $Al/Boria_w$	Toyota	Piston rings

Table 3: Contd.,		
Al/Al_2O_3	Dupont, Chrysler	Connecting rods
Cu/graphite	Hitachi	Current collectors
Al/graphite	Associated Engineering, Inc.	Cylinders, pistons
Al/TiC_p	Martin Marietta	Pistons, connecting rods
Al/fiberfrax	Zollner	Piston

CONCLUSIONS

This paper presents a review of the different manufacturing techniques and processing of AMMC's for usage in automotive industry. The technology of aluminum composite material is associated with the concept of high-performance reinforcements to strengthen conventional and high-performance matrix materials. Compare to standard materials the composite material offers mechanical strength, stiffness, weight; fatigue life and resistance to corrosion and wear are greatly improved. As stir casting technology, one of the methods for the manufacturing of composites is considered to be the low-cost processes when compared to the available manufacturing techniques for AMMC's. As a result, the composite materials are increasingly found in the structural materials in aerospace, automotive and metallurgical industries.

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